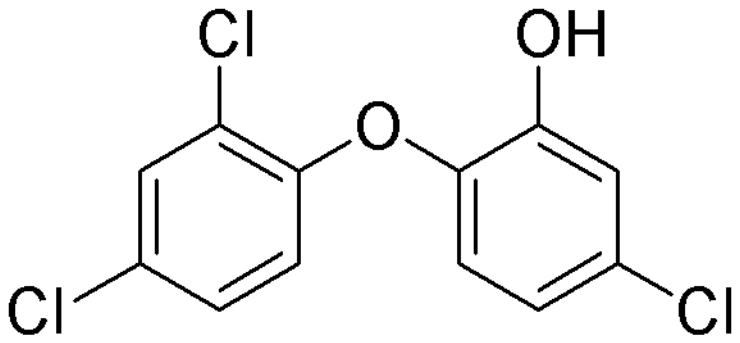
Pop Quiz

1. Did you wash your hands today?
2. Did you use liquid hand soap?
3. Was it antibacterial?
4. What made it antibacterial?

From triclosan to dioxins: How your handsoap leads to an unanticipated environmental problem

William Arnold
Department of Civil Engineering
College of Science and Engineering

Triclosan



triclosan

- Broad-spectrum antimicrobial
- Introduced in 1960s
- Increased rapidly in 1980s-90s
- Found in many personal care products
  - Handsoap
  - Toothpaste
  - Footwear
  - Acne creams
  - Plastics

Anti-bacterial handsoap: From obscurity to ubiquity

Anti-bacterial handsoap: From obscurity to ubiquity

The New York Times

January 8, 1981

Liquid Soap Grows Steadily

Those bits of soap that slip through fingers, dissolve into jelly or slide down the drain may be a problem of the past. At least that's the claim of the makers of "liquid soap," the hottest entry in the soap market.

Liquid soap, packaged in plastic pump-type dispensers, was first developed by Minnetonka Inc., a relatively obscure company based in Chaska, Minn. Minnetonka, founded with $3,000 in 1964, last year sold about 75 percent of all liquid soap in the country with its Softsoap brand.

Anti-bacterial handsoap: From obscurity to ubiquity

The Associated Press
June 22, 1984

Soap Companies Lathered Up Over Liquid Soap Ad

MINNETONKA, Minn. - The makers of Dial soap are in a lather over a magazine ad for a liquid cleanser that showed disease-causing microorganisms superimposed over a picture of a soap bar.

The ad by Minnetonka Inc. for its Softsoap and Derma Scrub liquid soaps is deceptive and sensational, says John Heinze, chief of microbial testing for Armour-Dial Inc., based in Scottsdale, Ariz.

Liquid soaps make up 10 percent of the $1 billion hand soap market

Anti-bacterial handsoap: From obscurity to ubiquity

Advertising Age
October 26, 1987

Liquid Dial fights germs
Jennifer Pendleton

Dial Corp. is re-entering the $120 million liquid-soap business with a liquid version of its venerable Dial deodorant soap and an unusual marketing strategy.Unlike its competitors in this growing segment of the $1.2 billion hand-and-body soap market, Liquid Dial contains an anti-bacterial ingredient called Triclosan that the company says can help stop the spread of cold and flu-causing germs.

TV commercials breaking this week in the distribution areas show a mother, father and child in a bathroom talking about Liquid Dial's anti-bacterial properties as the reason they switched from their regular soap. The spots also will point out that Liquid Dial is the only product in the category to contain such an ingredient.

Anti-bacterial handsoap: From obscurity to ubiquity

Advertising Age
July 24, 1989

Dial, Softsoap face germ war
By Laurie Freeman

Dial Corp.'s Dial anti-bacterial liquid soap is cleaning up in the revitalized segment, and liquid pioneer Softsoap is ready for a fight. Dial's pump-dispensed liquid has been available nationally less than a year but has already helped boost year-to-date sales in the liquid soap segment to $200 million, up 73.9% from last fall. The segment now represents 13.3% of the $1.5 billion toilet soap category.

Softsoap, a Colgate-Palmolive Co. division, will aim to solidify its position this fall with the introduction of its own pump-dispensed, anti-bacterial extension.

Anti-bacterial liquid soaps now represent 23% of liquid-soap sales and account for more than half the segment's growth.

Anti-bacterial handsoap: From obscurity to ubiquity

Triclosan used in 76% of commercial liquid handsoaps *Environ. Health Persp.* **2001**, *109*, A18.

Why 1987?

1987: Dial Anti-bacterial

AIDS

The Hot Zone

Ebola

Outbreak

Avian Flu

SARS

Anti-bacterial handsoap: From obscurity to ubiquity

Business Wire
September 20, 2007

No Crest For the Anti-Bacterial Wave

CHICAGO - Heightened levels of "germaphobia" have given rise to a huge influx of new [anti-bacterial] products…[which] increased from fewer than 200 worldwide in 2003 to some 1,610 in 2006 - an impressive 713% growth.

~~I~~nterest in anti-bacterial products first came to light in the early 1990s. But more recently the market has picked up again on the back of the SARS epidemic of 2002-2003, outbreaks of avian flu, and other high profile stories such as superbugs in hospitals across Europe and the UK in particular," comments Lynn Dornblaser.

Some 71% of American adults…"prefer anti-bacterial and germ-killing cleaning products". It is the youngest adults, aged 18-24, who are the most likely to agree with this statement (80%), which bodes well for the future of these products as these young adults are likely to take their cleaning preferences with them as they age.

New triclosan containing product?

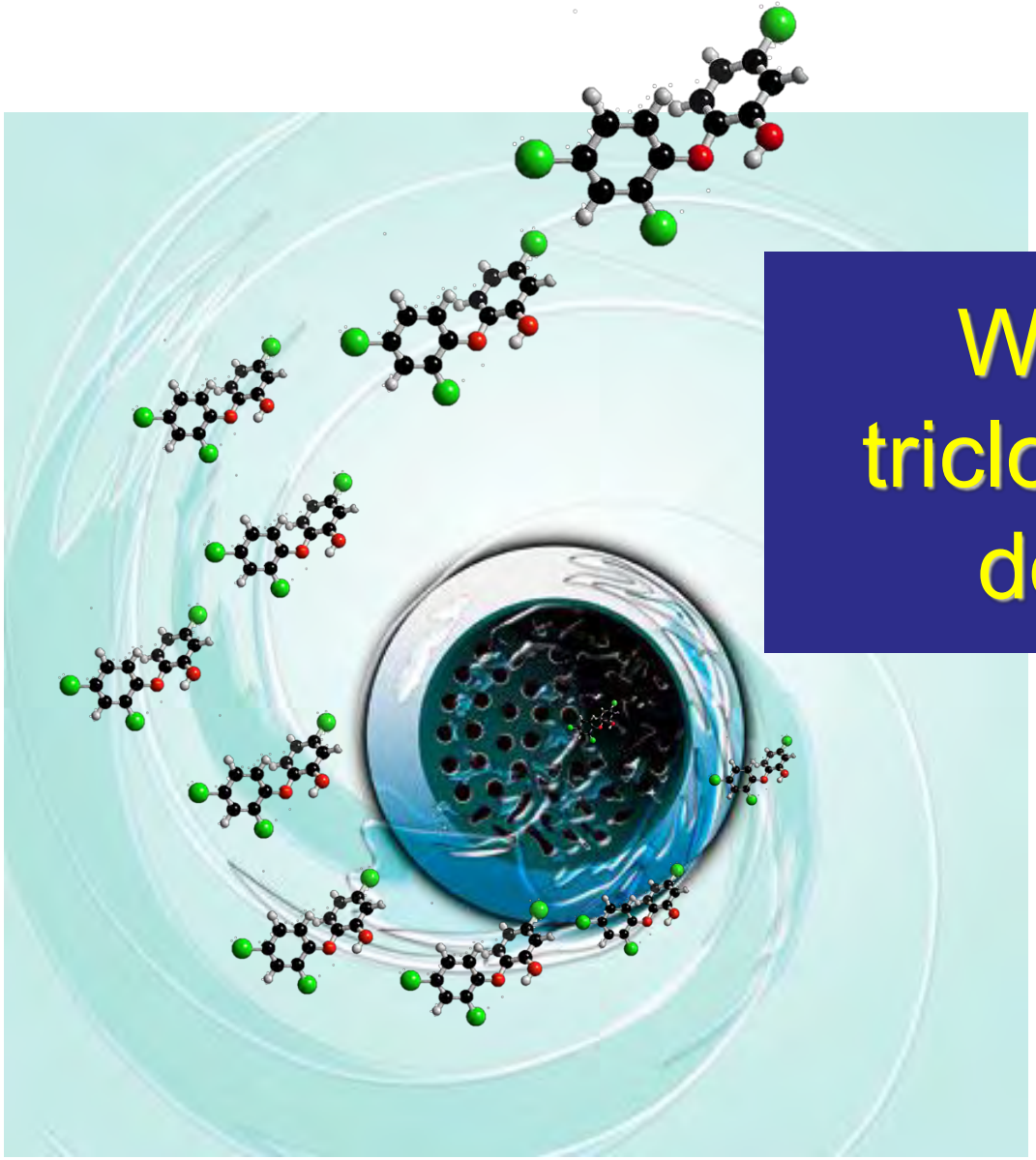
French's Introduces Antibacterial Mustard

April 13, 2005 | Issue 41•15

ROCHESTER, NY—In response to increasing American demand for tangier, more hygienic meals, condiment giant French's has introduced a new antibacterial mustard.

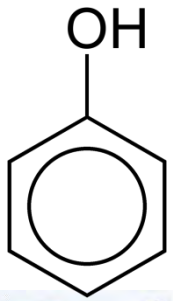
"Each year, 15 million cases of bacterial food poisoning originate in U.S. home ...

Source: The Onion, April 13, 2005



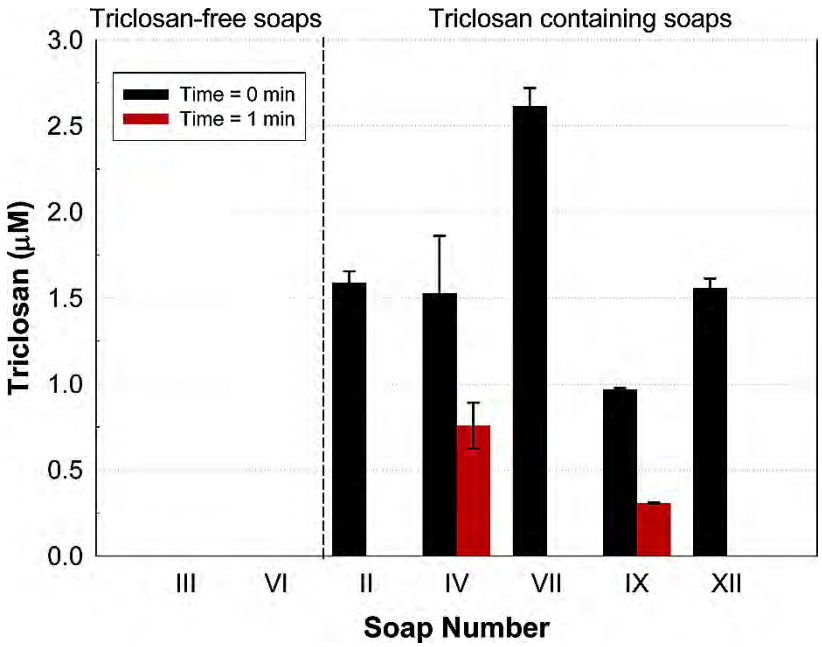
What happens to triclosan when it goes down the drain?

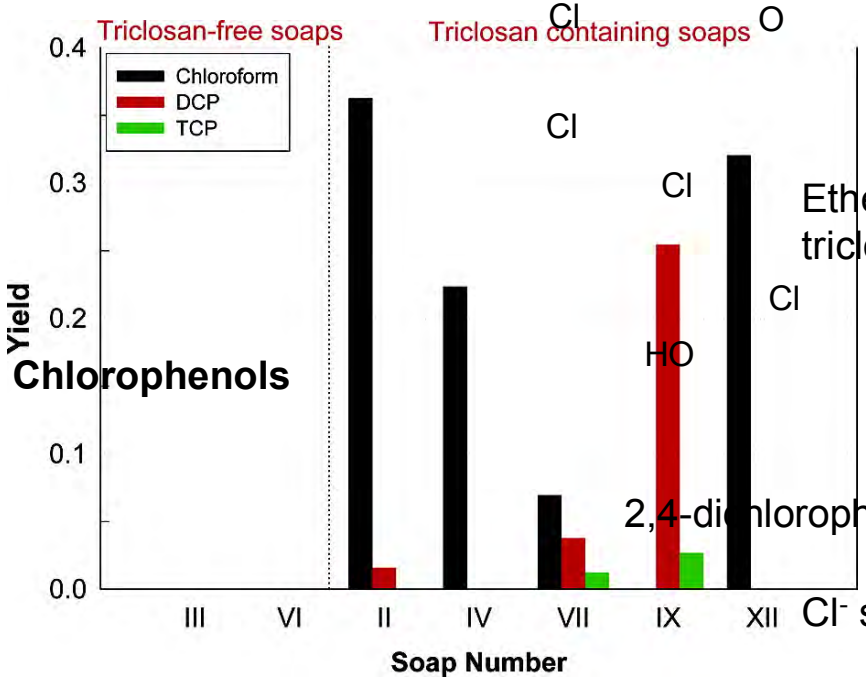
Triclosan is a type of chemical known as a phenol

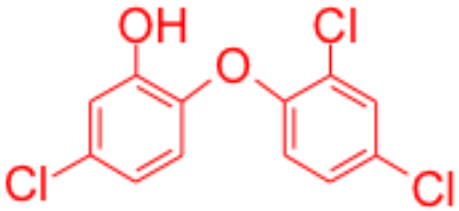


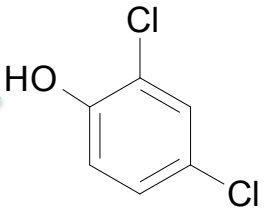
- Phenols have a long history of use as disinfectants
- Unfortunately, phenols readily react with the disinfectants used for drinking and wastewater treatment…

Triclosan present in soaps can degrade to produce products of potential concern.









Fiss et al. (2007) *Env. Sci. Technol.*

Int A

Cl⁻ substitu

OH Cl

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Cl

Cl

Cl

Ether cleav
triclosan or

Cl

HO

Cl

2,4-dichlorophenol

Cl⁻ substitu

Chlorophenols

Cl

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Cl Cl

2,4,6 – trichlorophenol

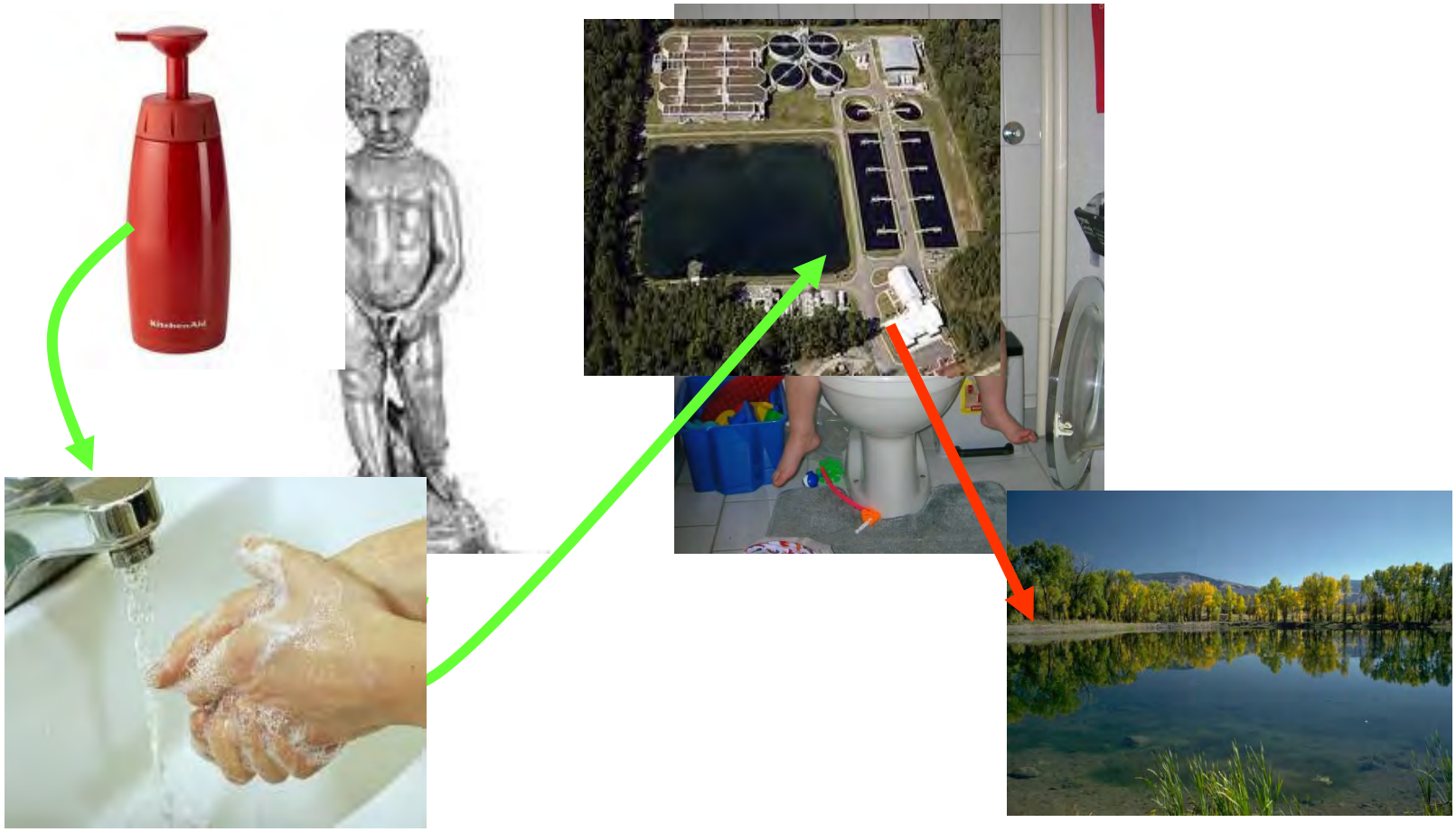
Ring cleava
or chloroph

Trihalomethanes

$CHCl_3$

Chloroform

Route to the Environment



Triclosan and its degradation products travel down the drain to wastewater treatment facilities.

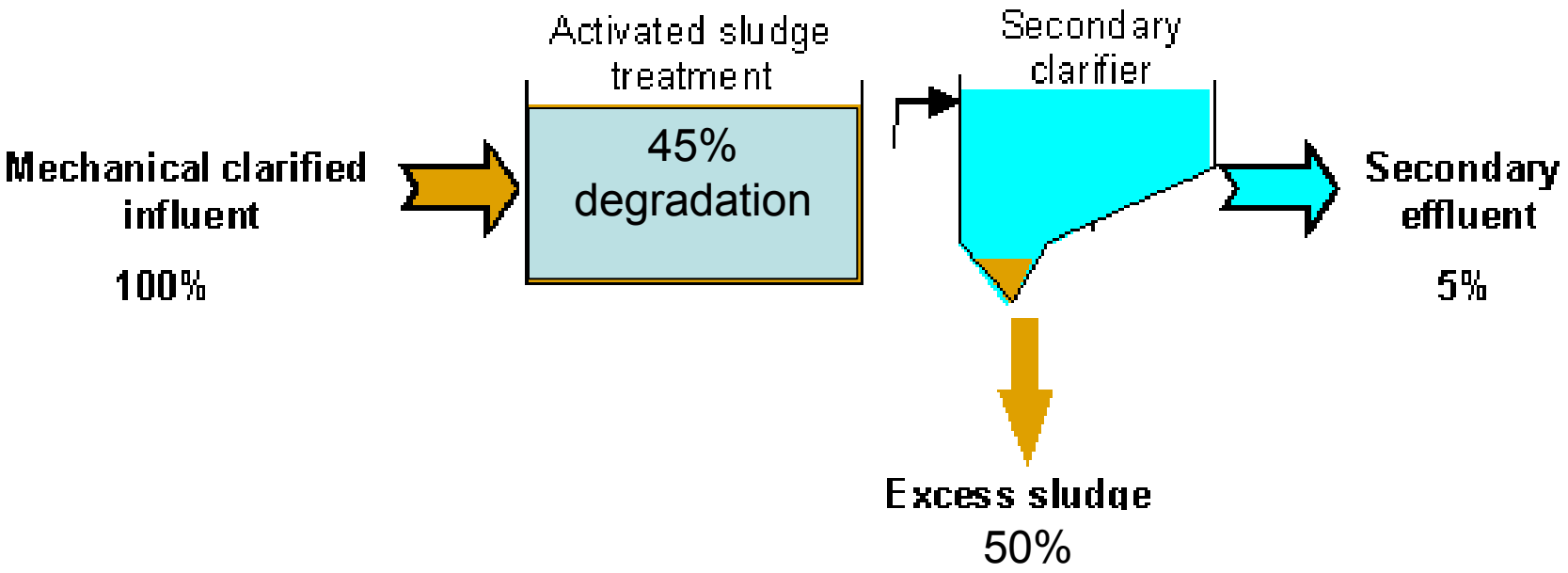
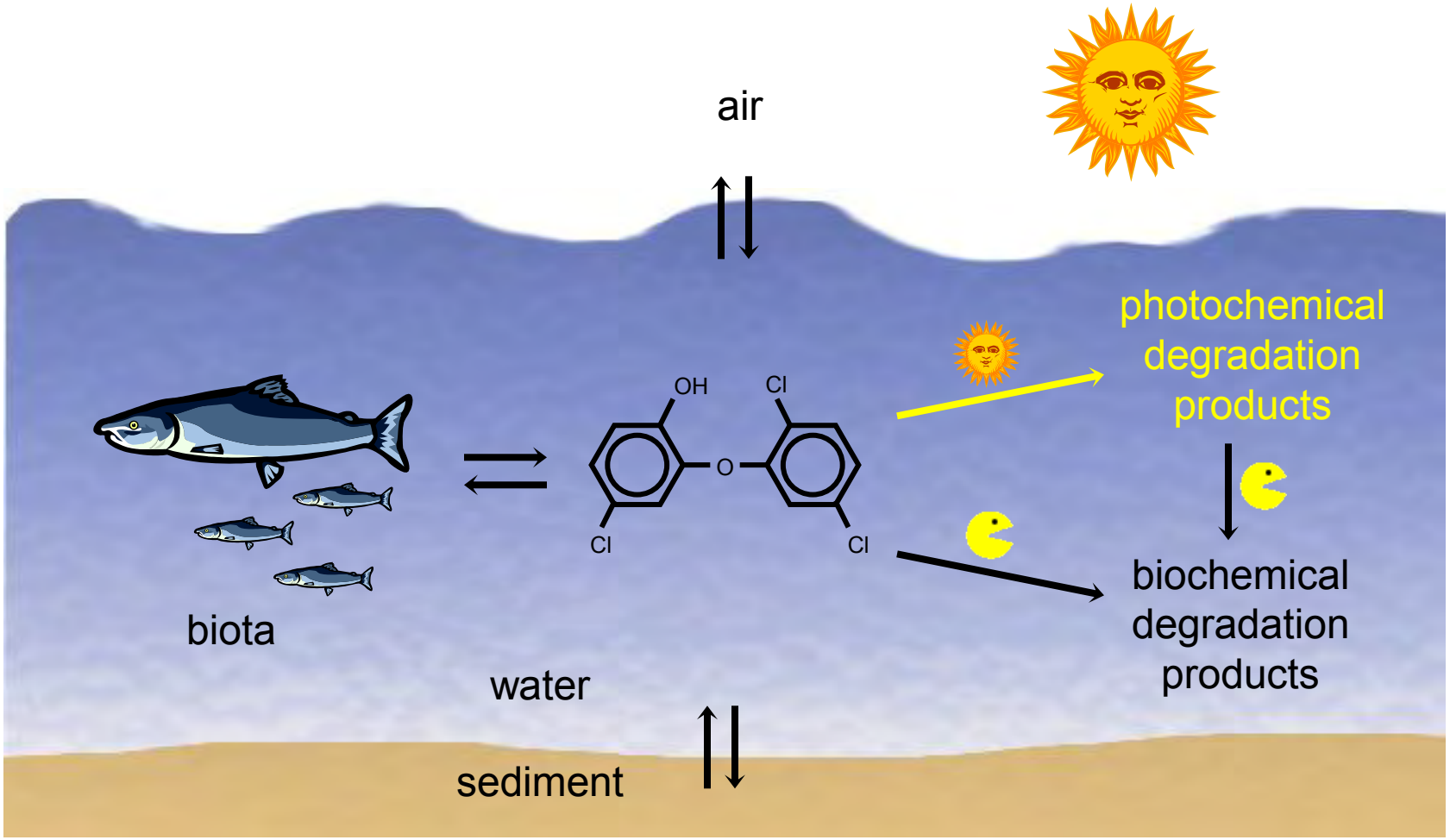


Fig. 1: Mass flow of triclosan in a waste water treatment plant

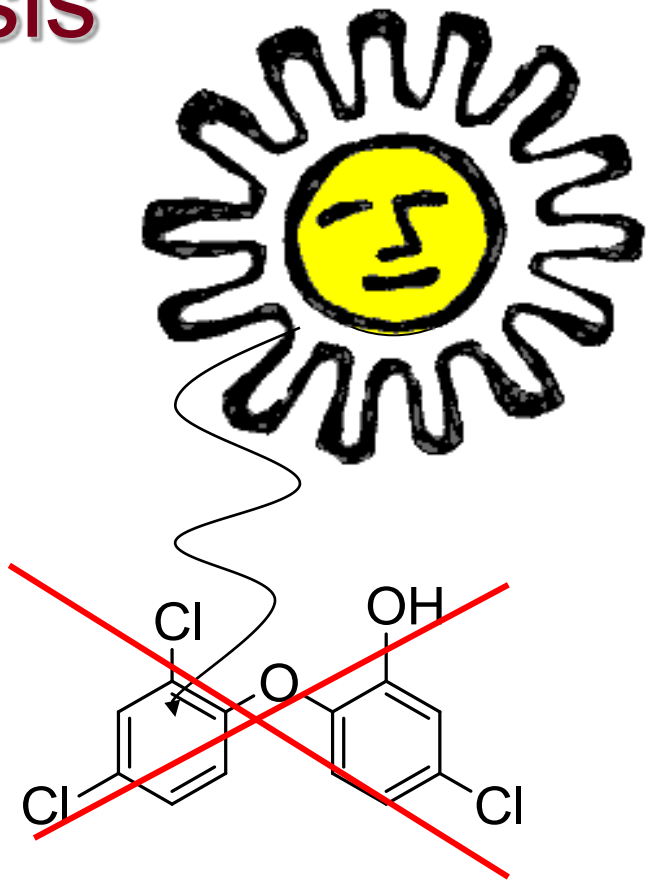
The other shoe drops

- Triclosan detected in
  - Surface waters (μg/L)
  - Sediments
  - Fish
  - Breast milk
- 57% of U.S. surface waters in USGS study (1999-2000; Koplin et al., 2002)

Aquatic Environmental Fate

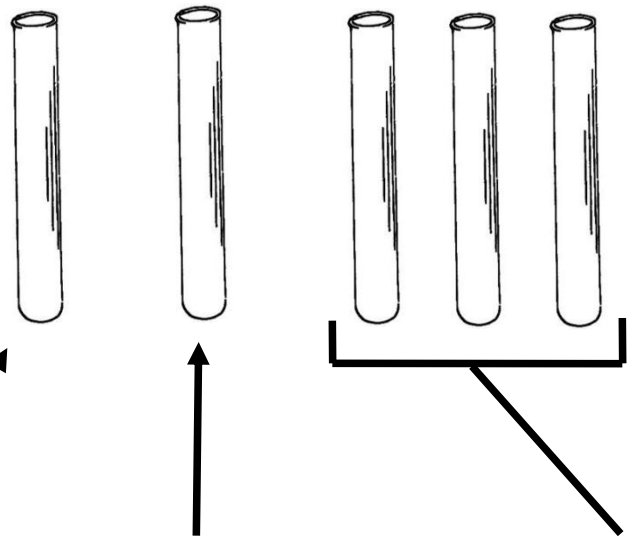


Photolysis

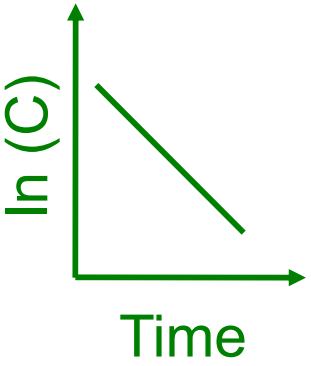


Experiments

Quartz test tubes



Time series via HPLC/UV-Vis



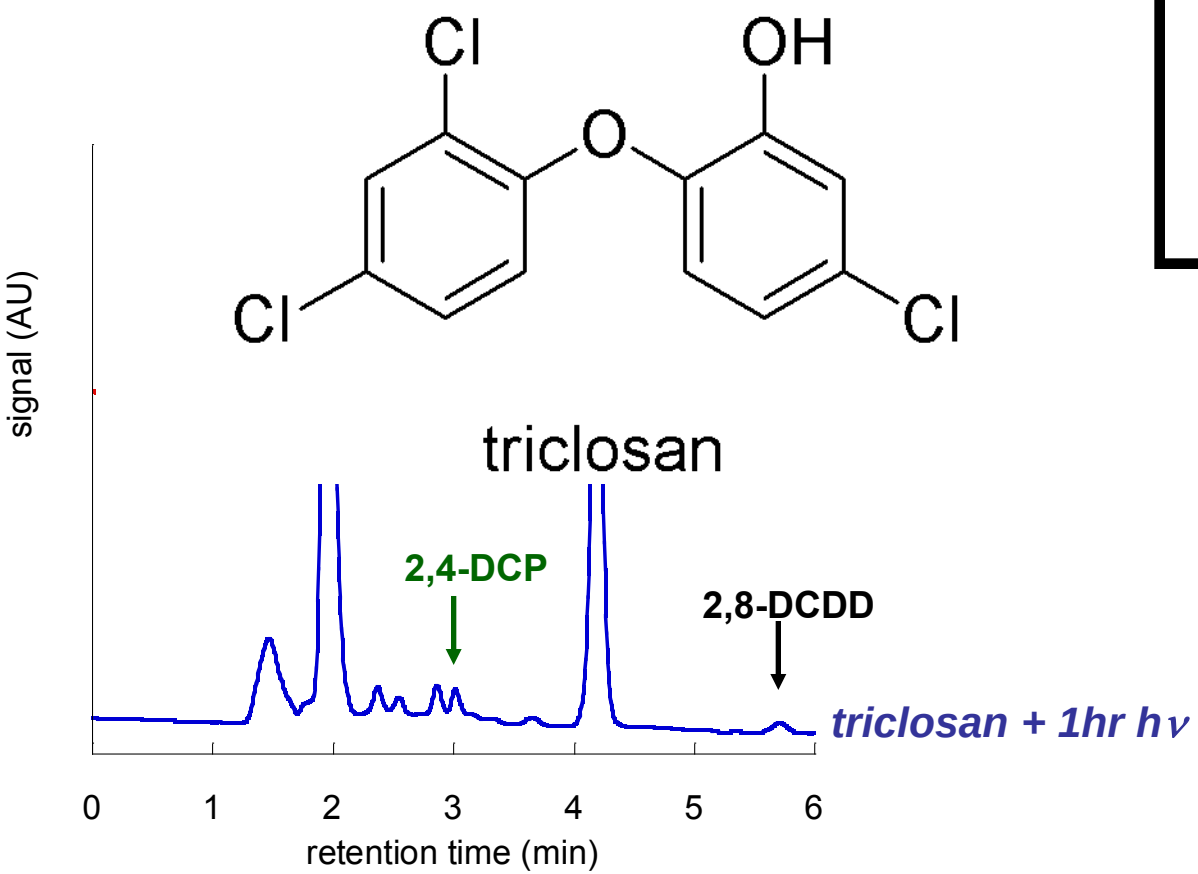
Actinometer (*chemical measure of light intensity*)

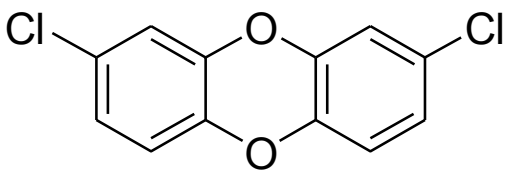
Compound of interest in ultrapure water

Other conditions (*vary the pH, water hardness, add natural organic matter, dark control*)

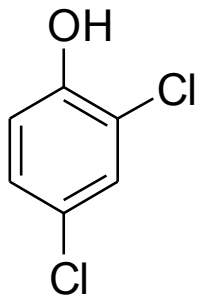
Reaction Products

HPLC analysis:



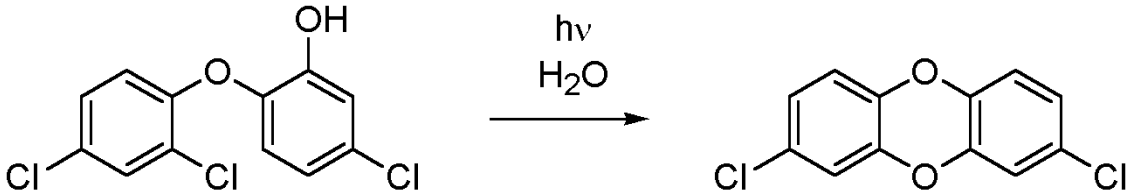


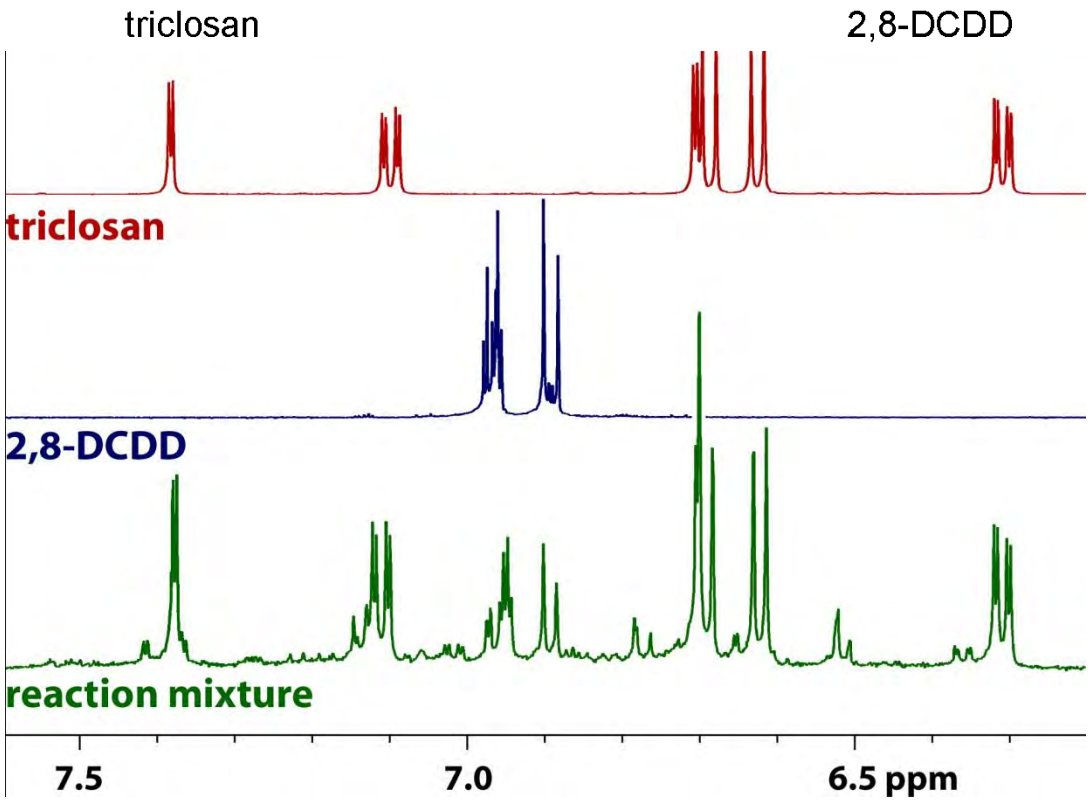
2,8-dichlorodibenzo-*p*-dioxin
(2,8-DCDD)



2,4-dichlorophenol
(2,4-DCP)

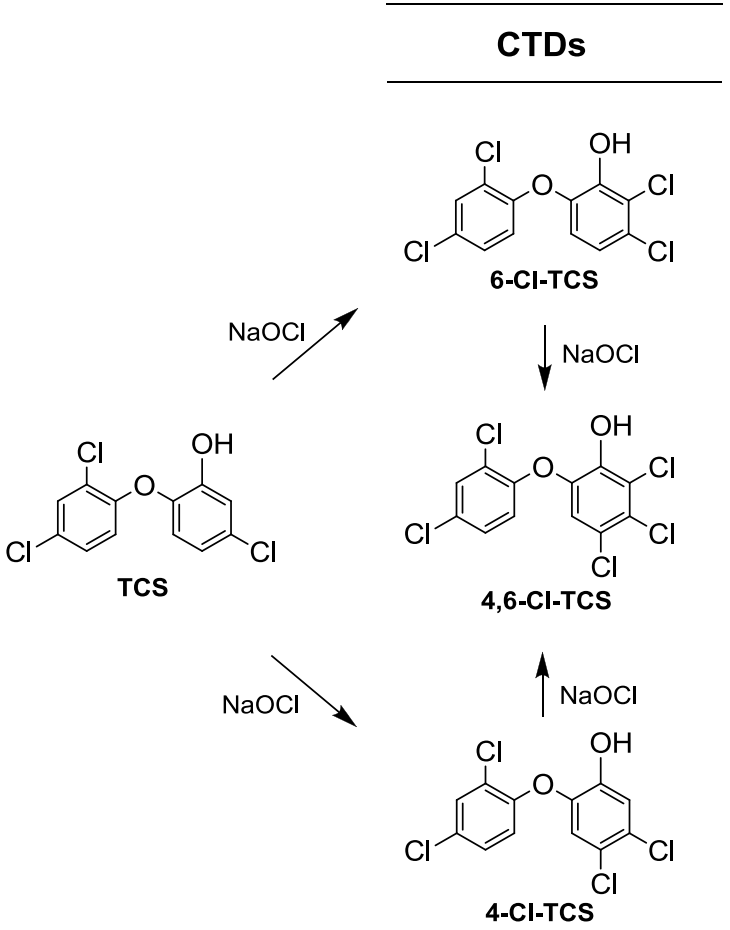
Triclosan to dioxin





Chlorinated Triclosan Derivatives (CTDs)

- Exposure to HOCl in tap water yields CTDs[1]
- CTDs detect in WW influent[2]



[1]Rule et al. *Environ. Sci. Technol.* 39:3176-3185.
[2]McAvoy et al. *Environ. Toxicol. Chem.* 21:1323-1329.

Wastewater is disinfected, too….

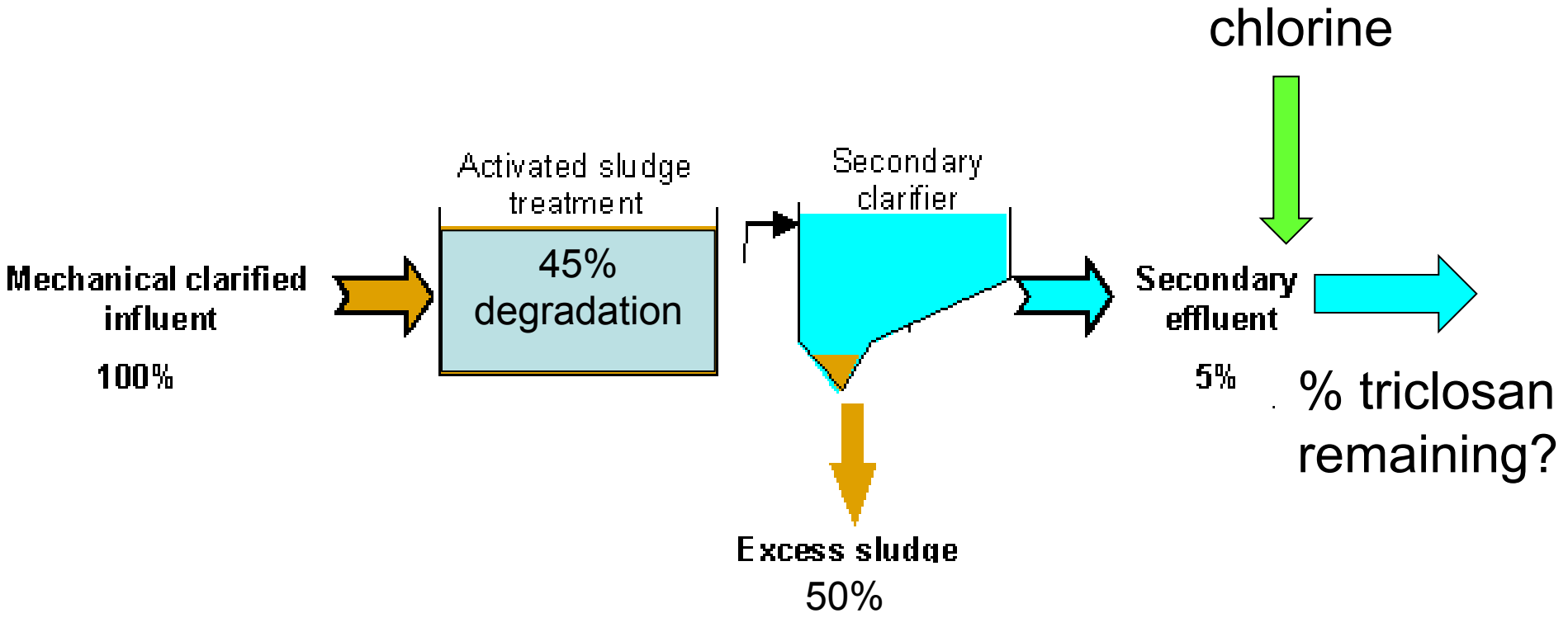
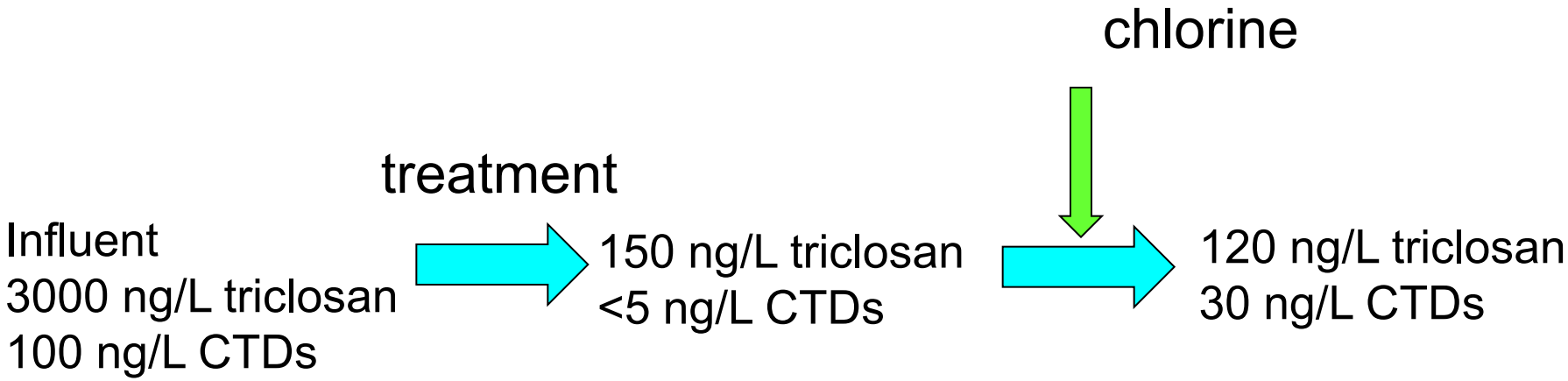


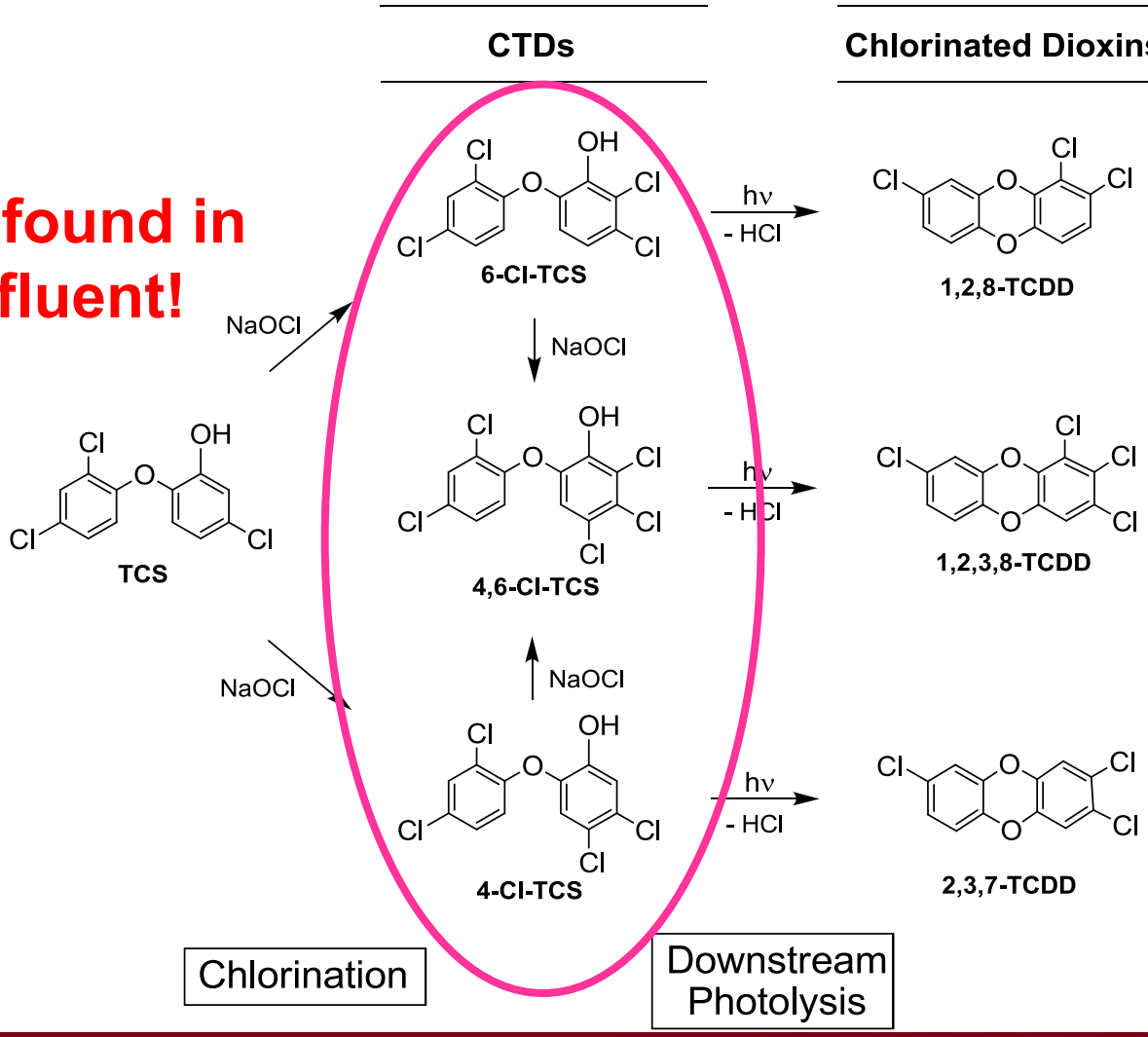
Fig. 1: Mass flow of triclosan in a waste water treatment plant

What happens to the triclosan and CTDs?



Dioxins from CTDs?

We've found in WW effluent!



Dioxins from CTDs

- Yes
- Same mechanism as triclosan
- More chlorines = more toxic = greater environmental concern

But are these dioxins really produced in aquatic systems?

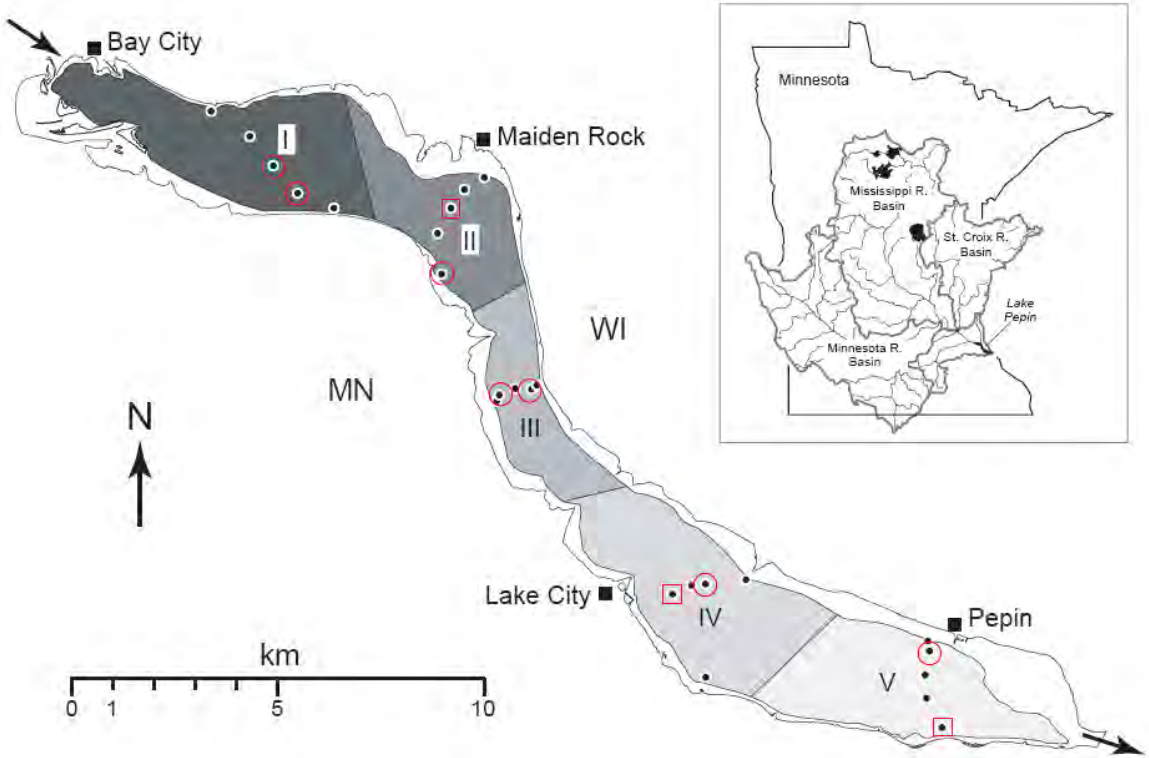
(and where do they come from?)

The proof is in the…~~pudding~~ …sediment

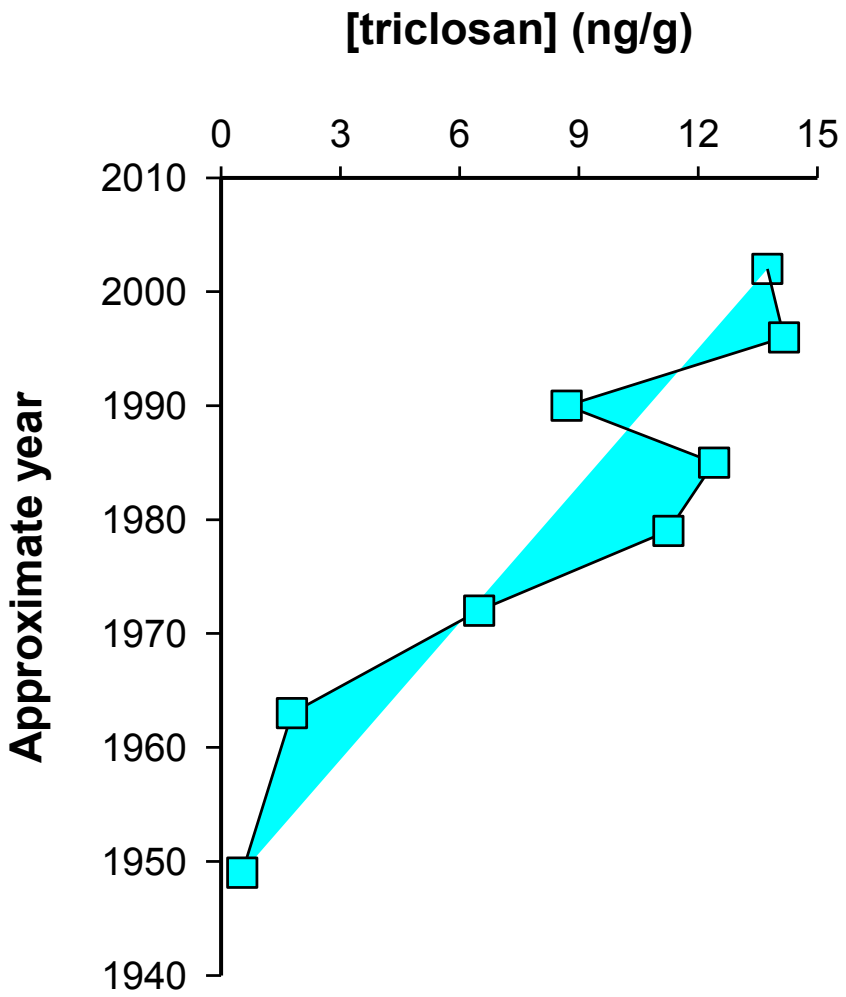
- Dioxins are stable
  - Sorb to particles
  - Deposit/accumulate in sediments
    - Sediments serve as integrators of pollution
- Recall
  - Triclosan introduced in 1960s
  - Usage grew rapidly in 1980s-2000

Dioxins in the sediment?

- Analysis of Lake Pepin sediment cores

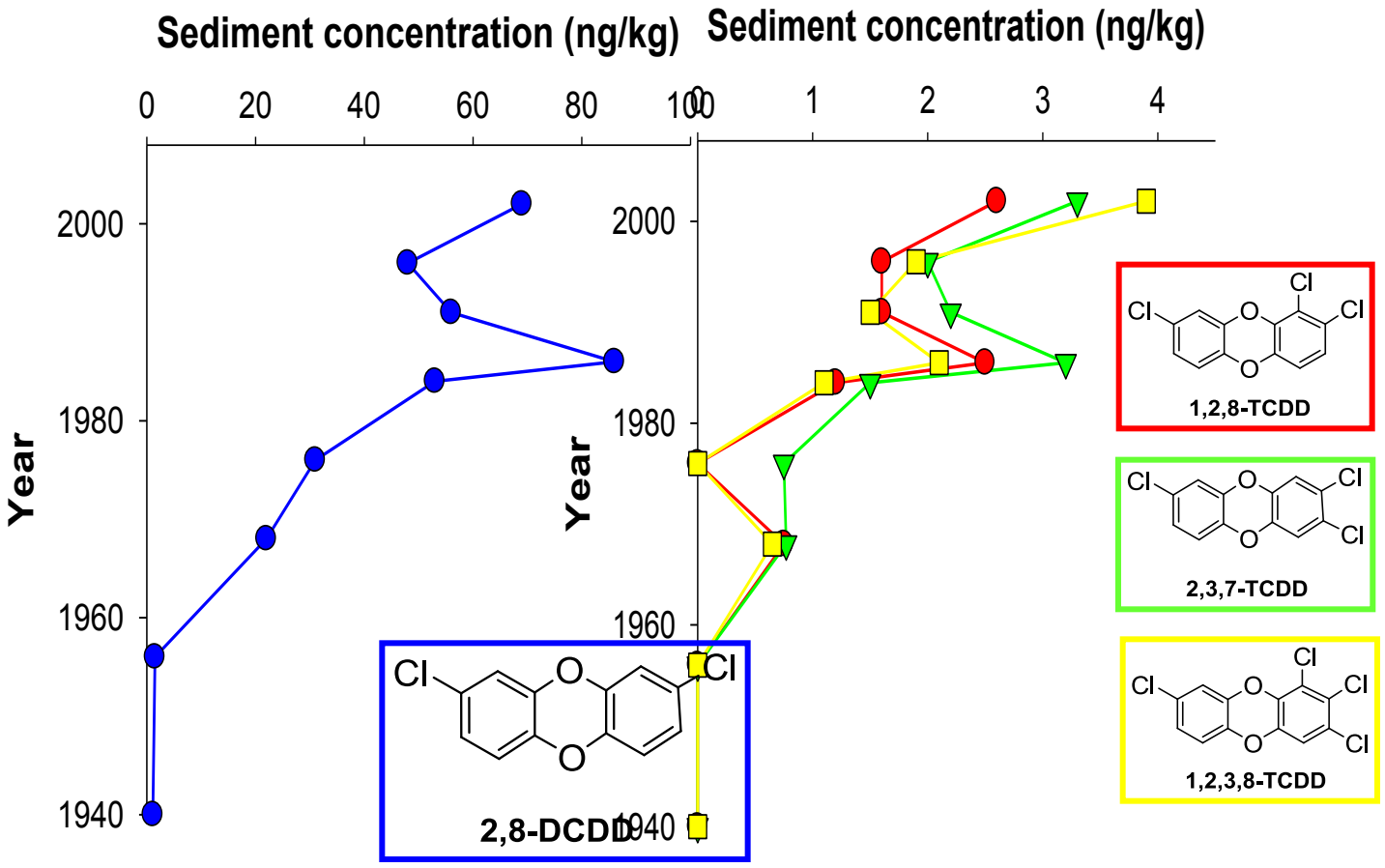


Sediments: Triclosan

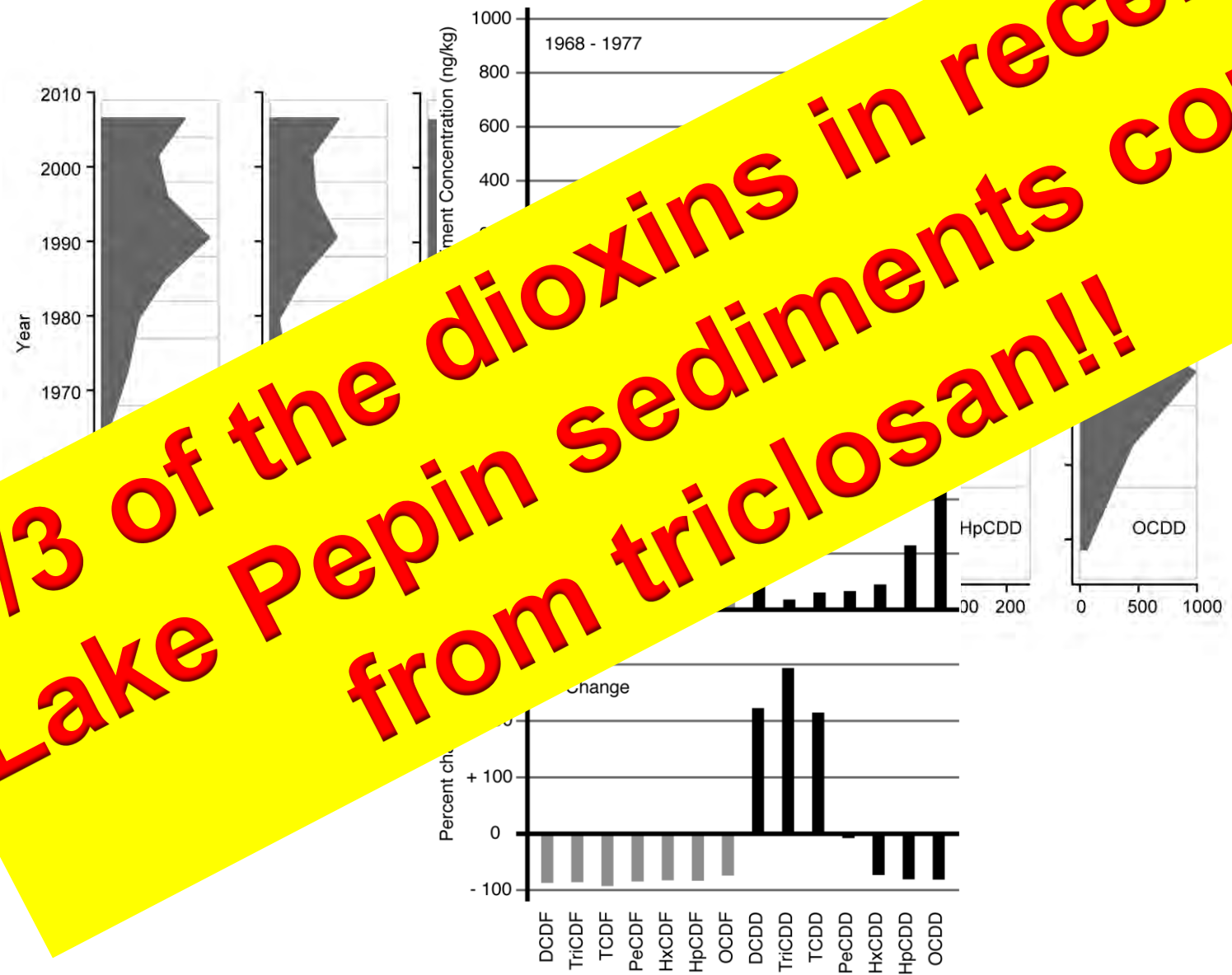


Sediments: Dioxins

~100% of di- and trichlorinated dioxins consistent with triclosan as the source



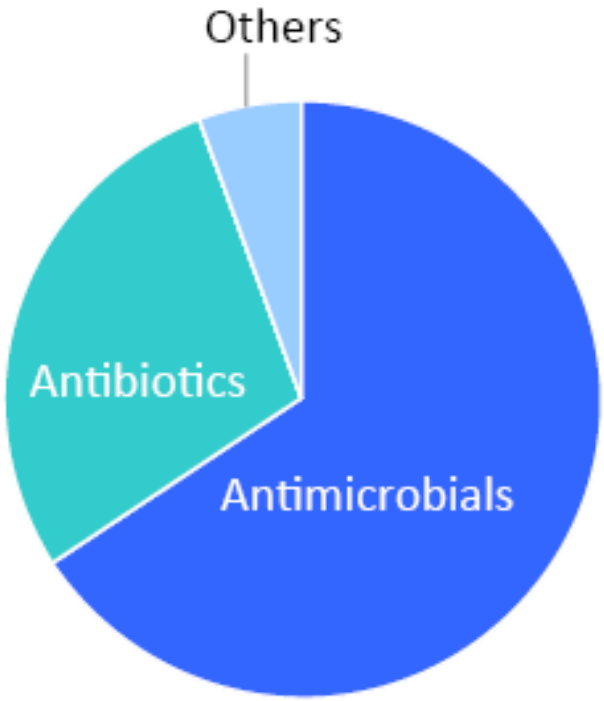
Sediments: Dioxin



1/3 of the dioxins in recent Lake Pepin sediments come from triclosan!!

Other problems

- Sludge/biosolid
  - 15 mg triclosan/kg
  - Land applied
    - Affects bacteria
    - Uptake to food or biota
  - Incinerated
    - Dioxins?

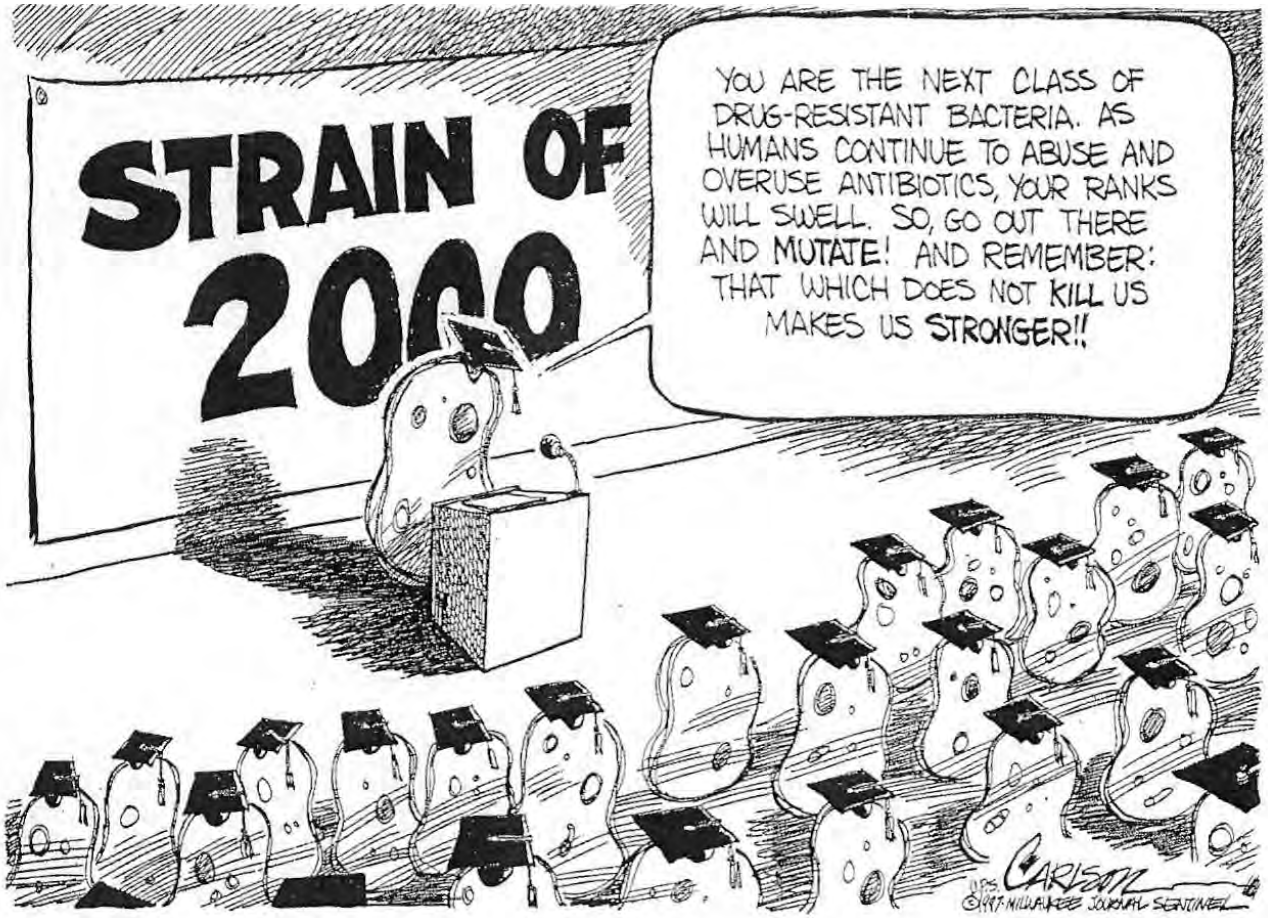


2/3 of the —pharmaceuticals" in wastewater biosolids come from soap!

Halden et al. 2010

Other problems

- Triclosan is toxic to algae
- Bacteria can develop resistance to triclosan



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At the Orange County Sanitation District, a settling basin is used to filter water as part of the advanced secondary treatment, before the water is diverted into the ocean, in Fountain Valley, Calif. Pharmaceuticals in waterways are damaging wildlife across the nation and around the globe, research shows.

By Ric Francis, AP

AP: Drugs found in drinking water

Updated 9/12/2008 2:02 PM | Comments 149 | Recommend 87 E-mail | Save | Print | RSS

By Jeff Donn, Martha Mendoza and Justin Pritchard, Associated Press

A vast array of pharmaceuticals — including antibiotics, anti-convulsants, mood stabilizers and sex hormones — have been found in the drinking water supplies of at least 41 million Americans, an Associated Press investigation shows.

To be sure, the concentrations of these pharmaceuticals are tiny, measured in quantities of parts per billion or trillion, far below the levels of a medical dose. Also, utilities insist their water is safe.

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Is this a problem?

What is the solution?

Acknowledgements

- Kris McNeill, Doug Latch, Jennifer Packer, Jeff Buth, Dan Engstrom, Deb Swackhamer, Peter Vikesland
- Pace Analytical (Chuck Sueper)

http://dx.doi.org/10.1897/08-490.1

http://dx.doi.org/10.1021/es9003679

http://dx.doi.org/10.1021/es1001105